UNIVERSAL DESIGN OF A FUTURE GROCERY RETAIL CHECKSTAND

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Camilo A. Vargas

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UNIVERSAL DESIGN OF A FUTURE GROCERY RETAIL CHECKSTAND

Approved by:

Dr. Abir Mullick, Advisor
School of Industrial Design
Georgia Institute of Technology

Dr. Jon Sanford
School of Architecture
Georgia Institute of Technology

Dr. Karen Milchus
School of Architecture
Georgia Institute of Technology

Date Approved: July 7, 2008

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

SUMMARY

This project is part of CATEA's RERC workplace accommodations grant, and it d research, develop, test and evaluate a retail checkout workstation that maximizes independence and participation of employees and increases their employment possibilities. Preliminary research shows that current designs of retail checkout workstations do not accommodate the intended employees including the seated and standing users. According to the research, factors like task design and ease of use have contributed to job loss and reduced employment. Through participatory research techniques and ergonomic studies, this project identified accessibility and usability needs and outline design guidelines of a retail workstation that would address these needs. Based on these guidelines and examining possible future retail checkout scenarios influenced by new trends and emerging technologies, future grocery retail checkout concepts were developed. These concepts try to address the need for wider accessibility and better interactions, while adding value through design that aims to increase job opportunities for people with disabilities provide a better experience for the end users and maximize store investment efficiency of front-end equipment.

CHAPTER 1

INTRODUCTION

This thesis project is a continuation of the universal design of a grocery retail checkout project within CATEA's Rehabilitation Engineering Research Center on Workplace Accommodations (Work RERC). That grant focuses on the development of new designs for workstations in environments where accessible workstations are not available. Prior to this project, key background information had been gathered, and a pilot study involving individuals with different functional abilities, their reach difficulties and preferred checkstand work heights had been conducted. These studies illustrated the need for a universally designed retail checkstands capable of accommodating a wider range of checkout employees. While this project's main focus is on the needs of the intended users of grocery retail checkout workstations (employees and customers), needs of other stakeholders like corporate management and manufacturers were part of the decision making process. Through participatory research techniques and ergonomic studies, this project identified accessibility and usability needs and outline design guidelines of a retail workstation that would address these needs. Based on these guidelines and examining possible future retail checkout scenarios influenced by new trends and emerging technologies, future grocery retail checkout concepts were developed. These concepts try to address the need for wider accessibility and better interactions, while adding value through design that aims to increase job opportunities for people with disabilities provide a better experience for the end users and maximize store investment efficiency of front-end equipment. Thus, there is a business case for implementation these new designs.

Purpose of This Research

The main purpose of this thesis was to develop a practical and useful set of universal retail checkout workstation design guidelines that will accommodate a wider population of employees, including those with functional limitations. These guidelines and qualitative research data were used to design concepts of future grocery retail checkout workstations. These designs incorporate a synergy of human factors, inclusive design and participatory research, as well as to help build a business case for universally designed retail checkstands within the context of a near future.

Significance of study

In work environments where accessible workstations are not available, the participation of diverse individuals, including those with functional limitations, is limited. This thesis project as part of the Work RERC focuses in the use of universal design concepts - *the design of products and environments to be usable by all workers, to the greatest extent possible, without the need for adaptation or specialized design* (*"Workplace RERC", n.d).*

The grocery retail market was identified as a valuable and challenging environment to put this in practice. Preliminary research indicated that the grocery retail market currently employs a high number of people (over 5.5 million) and is among the top ten occupations with the largest job growth over the next decade (US Department of Labor). Although these jobs have a relatively low physical demand, factors like job task and workplace design have limited accessibility and contributed to job loss and reduced employment. Thus, there is a great potential for impact in the development of new designs for workstations in retail settings where accessible workstations are not available.

Among the key motivations for this research is the value of designing for the needs of end users who are currently not involved in any decisive stage of the design, purchase or planning process of a workspace, yet are directly affected by the strengths or weaknesses of a design. Through an integral design process and participatory research this project identified accessibility and usability needs and outlined design guidelines of a grocery retail checkout workstation that will provide appropriate affordances for all users so they can work safely, comfortably and efficiently.

CHAPTER 2

BACKGROUND RESEARCH

Literature Review

The background research was conducted using a variety of methods, including electronic databases like Pubmed, ScienceDirect, Ergonomics and Compendex, Georgia Tech library books, review of interviews of retail managers and cashiers , in addition to Google searches that provided up to date articles about the retail industry. This review identified domains relevant to the project. These include:

- Retail infrastructure and business practices
- Ergonomics and analysis of retail checkout tasks
- Previous Universal Design Checkstand project
- Competitive product analysis
- Future of retail checkout

Infrastructure and Business Practices

In 2004, major grocery stores or supermarkets provided 2.4 million jobs in their 85,000 locations across the United States ("US Department of Labor, Bureau of Labor Statistics", 2004). Employment will grow as the population increases and as more grocery stores offer a wider array of goods and services. Unlike many other industries, the grocery industry is not highly sensitive to changes in economic conditions. Even during periods of recession, demand for food is likely to remain relatively stable. Many additional job openings will arise from the need to replace workers who transfer to jobs

in other industries, retire, or stop working for other reasons. Replacement needs are particularly significant due to the industry's large size and the high turnover rate among cashiers and other workers who do not choose to pursue long-term grocery industry careers ("US Department of Labor, Bureau of Labor Statistics", 2004).

Cashiers make up the largest occupation in grocery stores, accounting for 34 percent of all workers. At the grocery front end, the employment positions/hierarchy is as follows: store manager, sales worker supervisor, head cashier, cashier, and bagger. The main duties of cashiers are to scan and bag customer's purchases, receive cash, personal checks, credit or debit cards payments, and make change. When cashiers are not needed to check out customers, they sometimes assist other workers ("US Department of Labor, Bureau of Labor Statistics", 2004). Cashier jobs are considered entry-level and can be learned in a short time. The majority of training is done on the job, and only lasts a few days. It includes: observing an experienced cashier, learning store policies and procedures, and finally, working with a trainer on an assigned register until the trainee becomes familiar with the job tasks. Desired attributes in a cashier generally include: friendly and dependable, able to do repetitive work quickly and accurately, understanding of basic arithmetic skills, good hand-eye coordination, good memory, manual dexterity, and high school graduates are typically preferred (O-Net, 2004).

Turnover Rate

Turnover is a major concern for the grocery retail industry. A study about retention vs. turnover of the supermarket industry conducted by the Coca-Cola Retailing Research Council (Johnson & Tratensek, 2001) determined that the average cost of turnover for a supermarket employee making $7 was about $4,000. The study showed

that, from the more than 125,000 employees they tracked, half of the new hired people left the job within the first 97 days. Additionally, less than 30% of employees stayed on job for more than one year, and 25% of new hires quit within the first month. Employee retention drivers were also examined. It was concluded that increasing pay doesn't have a dramatic effect on employee turnover. A retailer would have to increase salary by $3/hr to reduce turnover by 10%. The top 3 retention drivers included providing directions, equipment and supplies, and immediate supervision. Also, a major factor in reduction of turnover was flexibility on the part of the employer – needs, schedules, salary, etc. Better hiring practices, such as automated application processes, may also lead to a lower turnover rate.

Key Findings and Implications for a Universal Design Retail Checkout Workstation

Turnover rates showed to be a major concern for retail stores, causing a large amount of overhead for companies. Although checkstand design plays a small role in turnover drivers, a better checkstand design that promotes a positive experience for employees and increased accessibility to accommodate a constantly shifting workforce may prove to improve retention rates and, in turn, corporate management interest in a universal design checkstand design. One aspect that has a direct implication in checkstand layout is the need to provide space for more than one cashier since cashier's training is done on the job by observing an experienced cashier. Another key point for consideration that can be addressed through design and could reduce task demands barriers is the currently arithmetic and memory skills required to accomplish tasks like counting money after the shift and memorizing codes for products. This can be addressed through a more intuitive and automated POS system.

Ergonomics and Analysis of Retail Checkout Tasks

Other important factors to consider in the design of a retail checkout workstation are checkstand layout and ergonomics and their physical impact on the cashier. The physical demands of a cashier's job include force, repetition, awkward postures and static postures (FMI, 1995.) In a study of US Commissaries, researchers observed cashiers working, on average, a total of 7.5 hours during a shift at a checkstand, where scanning and weighing items consisted of 5 hours, cleaning scanner window was done for 0.5 hours, and key pad entry comprised 2 hours of the shift. By law, cashiers must be relieved for a 15 minute break after 1.5 to 2.5 hours of continuous work. While the implementation of bar-code scanners has improved productivity and efficiency, the physical demands of the scanning action have taken a toll on workers' health. The rapid pace needed to maintain product flow has cashiers moving their wrists back and forth up to 600 times per hour. Over an eight-hour shift, cashiers may handle more than 6,000 pounds of groceries. Cashiers are measured on productivity, and are often rewarded for their speed (OSHA, 2004).

Specific tasks required for a cashier position include (O-Net, 2004):

- Scanning or keying in price of purchases
- Totaling the purchase
- Receiving payment and making change
- Customer Service
- Accepting returns and exchanges
- Counting money before and after shift

- Bagging or wrapping purchases
- Checking IDs for alcohol and tobacco purchases
- Other duties might include stocking shelves and “fronting” items

During these activities, cashiers might encounter several risk factors for injury (OSHA, 2004). The first risk factor is lifting items; repeated or awkward lifting of heavy objects can cause injury. Another risk factor is the performance of repetitive tasks for long periods of time without cessation. Awkward postures may also cause injury, such as leaning over counters, reaching above shoulder height, or over-twisting the trunk. Contact stress is the last major area of injury risk; contact with sharp or hard surfaces can also cause injury if the duration or repetition of contact is excessive. These awkward postures and gripping actions found in cashier’s job tasks have resulted in a dramatic rise in the number of Work-Related Musculoskeletal Disorders (WMSDs) to cashiers’ hands, wrists, elbows, shoulders, and backs (U.S. Department of Health and Human Services, 1997). Researchers (Johansson et al., 1996) suggest that the main occupational risks contributing to MSDs are shoulder load, static tension of the neck, shoulder, and arm muscles, highly repetitive contractions in the shoulder muscles, work at or above shoulder level, repetitive grasping, extreme deviations of the wrists, and repetitive lifting of loads. Key factors at task optimization for reducing MSDs are horizontal reach, vertical reach, repetitive stress, work height, line of sight, leg and low back fatigue, item weight, worker comfort and task design (OSHA, 2004).

“Performing work within the best and preferred work zones shown below facilitates productivity and comfort. Work is safest when lifting and reaching is

performed in these zones. Working outside these work zones results in non-neutral postures that may increase the risk of injury. It is particularly important to perform heavy lifting tasks within the best work zone" (OSHA, 2004):

> The preferred work zone for standing users is described as follows (OSHA, 2004):
>
> - As far forward as your hand when you hold your arm out straight.
> - A foot on either side of the shoulders.
> - Upper level at shoulder height.
> - Lower level at tip of fingers with hands held at the side.
>
> The best work zone for standing users is described as follows (OSHA, 2004):
>
> - As far forward as your wrist when you hold your arm slightly bent
> - As wide as the shoulders
> - Upper level at about heart height
> - Lower level at about waist height

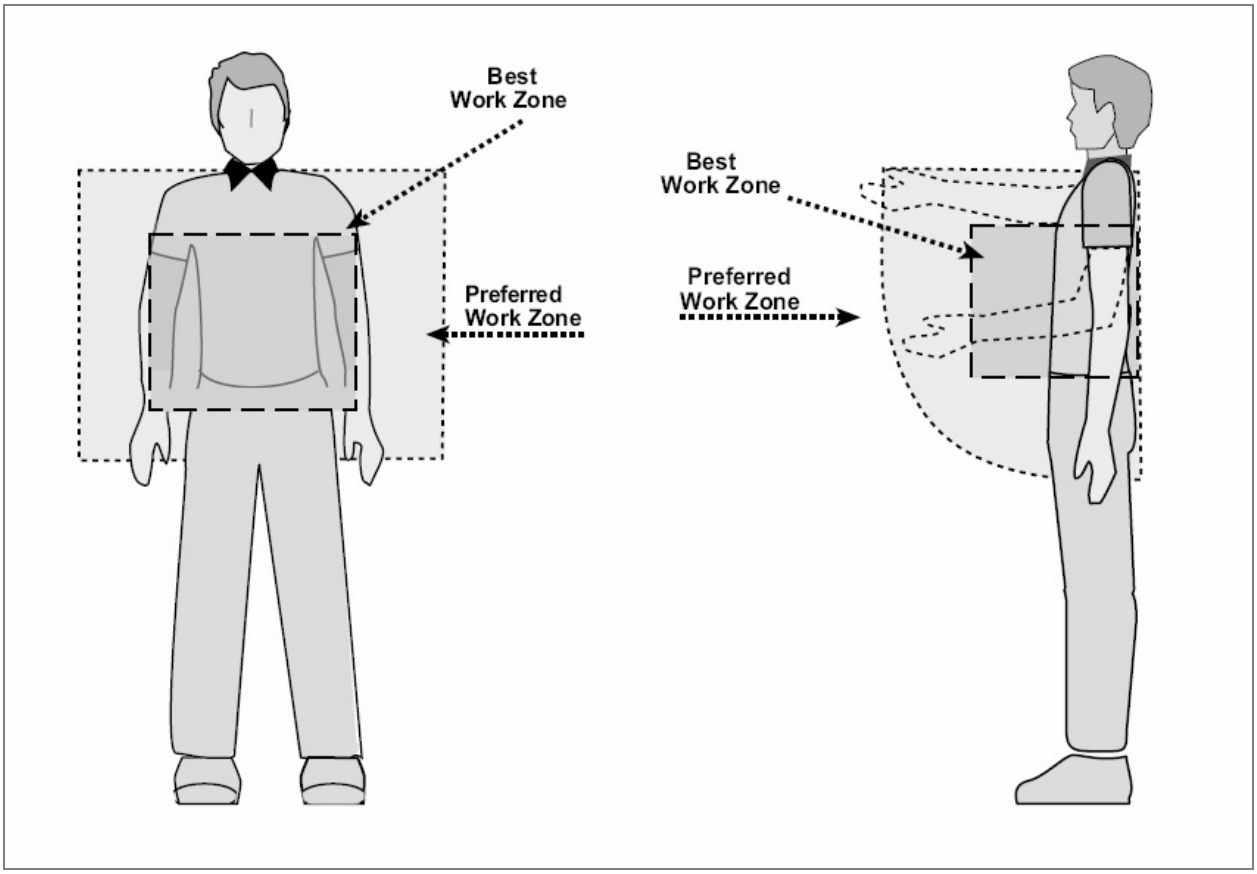

Figure 1 best and preferred work zones (OSHA, 2004)

A Key Issue in Seated vs. Standing Working Positions

Supermarket checkout work varies throughout the world depending on workstation design and the posture adopted while working. Supermarket checkouts in North America, Asia and Australia are typically designed to accommodate standing cashiers, while in Europe and South America, seated checkstands are the norm. An NCR study across different continents showed that despite differences in posture of cashiers, no geographical area or checkstand design is exempt from reports of musculoskeletal

disorders (MSD) or discomfort complaints (Lehman, Psihogios & Meulenbroek, 2001). Results indicated little difference in lower-back muscle activity between sitting and standing. Standing affords more favorable postures for the shoulder and arms, which produced lower activity in the neck and shoulder muscles. Other studies also show that standing positions provides lower muscle activity at all load levels than compared to sitting positions, however, the repetitive handling and the constant static load from standing were the main problems (Johansson, 1998). A checkstand offering both options of sit-and-scan and stand-and-scan would provide the greatest relief from fatigue, because cashiers would be able to alter their positions frequently (Lehman, Psihogios & Meulenbroek, 2001). In Europe, it is common that customers stand and bag their own groceries. As a result, the workload is shifted from the employee to the customer. This is culturally acceptable in Europe, but not yet in the US (Lehman, Psihogios & Meulenbroek, 2001).

Previous Universal Checkstand Project

The Universal Design of Grocery Retail Checkstands project began in fall 2005 with a team led by David Ringholz and a small group of students. The two main studies conducted were: 1) Determining Performance Requirements for Universal Design of Grocery Retail Checkstands and 2) Assessing Reach and Workstation Height for Universal Design of Grocery Retail Checkstands. For these studies a combination of quantitative methods and qualitative methods were used for data gathering. Quantitative Methods included anthropometry collection, reach, motion, and time measurement. Qualitative Methods included observations, interviews and a focus group discussion to collect subjective information. Participants included in the study were 6'0" and taller, 5'0"

and shorter, people had poor stamina or low energy, had difficulty reaching or manipulating objects, had inability to use upper or lower extremities or were pregnant women. The study Assessing Reach and Workstation Height for Universal Design of Grocery Retail Checkstands Findings (Ringholz, 2006) provided the following information:

- Definition of reach efficiency is described as the change in the center of mass (COM) divided by the reach distance
- The highest calculated reach efficiency value was 80% for a 156.5 cm tall, female who reached a distance of 84cm at a work height of 83.82cm.
- The lowest calculated reach efficiency value was 0% for a 177.3cm tall, pregnant female reaching 77cm at a work height of 99.06cm.
- The lowest recorded overall stature measurement was 135.3cm; the highest overall stature measurement was 193.8cm.
- The lowest recorded forearm height measurement was 64.4cm and the highest was 122.6cm.
- There was not a significant correlation between overall stature and reported preference in workstation height
- There was also not a significant correlation between forearm height and reported preference in workstation height
- There was a significant correlation between overall stature and work heights in which participants achieved their best reach efficiency value
- At a certain height for each user, COM deviation is minimized and reach is maximized

Key Findings and Implications for a Universal Design Retail Checkout Workstation

Cashier's main factors of injuries are the repetitive actions of scanning, the continuous effort of lifting items and awkward postures due to the limited working positions of current retail checkout checkstands. While the barcode scanner provides high productivity, it increases the physical demands on cashiers. To minimize this through design, scanners should be placed within the cashier's safe work zone and the infeed system should deliver items as close as possible to the scanner. Scanners also should be accurate enough to reduce failed scans. Lifting items is the second driver of cashier's injuries. A thoughtful placement and design of the bagging system should minimize lifting. Checkstand layout is the key variable of the design process. Every decision made over this variable influence the checkout workflow and thus all other aspects of the checkstand like component placement and cashier customer interaction. It is clear that the process of solving each variable of the design process is not linear but a complex array of variables closely related to each other. However, just like a mathematical equation, not all the variables can be solved at the same time and thus critical variables like checkstand layout should be addressed first. Another key aspect that will drive design is the need of the cashier to shift frequently working positions to reduce fatigue and injuries. There are a few possibilities to address this through design; one could be through work surface height adjustment. It can also be addressed by providing height adjustable stool or could be a combination of both. No matter what approach the design process should take, the main issue to address is the ease of use of this feature in order to provide with a practical and useful way to switch working positions.

Competitive Product Analysis

An evaluation of available products on the market was conducted in two areas: cabinetry and technology. These products were identified, classified and analyzed based on features, affordances and potential impact on cashier's job description.

The following are the four main types of checkstands used in major supermarkets in the US:

Belt Out feed:

Figure 2 Belt Out feed

This type of checkstand incorporates a take away belt after the scanner which moves the items closer to the bagger or the customer.

Drop in bag well:

Figure 3 Drop in bag well

This type of checkstand provides a bag well after the scanner which reduces lifting items for bagging.

Carousel bagging:

Figure 4 Carousel bagging

This type of checkstand provides a carousel system for bagging, allowing the cashier to have multiple bag stands in a rotating device.

Self – checkout:

Figure 5 Self-checkout

In this type of checkstand, customers themselves scan and bag their purchases, and pay using an automatic payment terminal. Sensitive weight scales under the bag stands are commonly used as a security device to avoid shop lifting.

The following are checkout technologies that stood out from others because of their potential to reduce injury, increase accessibility or add value to the shopping experience.

IBM Smart scale

Figure 6 IBM smart scale

This scale, developed by IBM, incorporates image recognition technology to automatically identify produce and print the corresponding price ticket without the need of further input by the customer.

Handheld Scanners

Figure 7 Handheld scanner

Handheld scanners are used to scan items that are difficult to pass over the traditional scanner. It allows the cashier or the customer to scan a large item without unloading it from the shopping cart. They are very useful in “Do It Yourself” (DIY) stores.

Touch-Screen Monitors

Figure 8 Touch Screen

Point of sale (POS) systems with touch-screen monitors offer a great flexibility for data input. Since the touch sensitive screen is the input mode, the possibilities of a better and more intuitive interface are increased compared to a keyboard type mode of input. In this case, the graphic user interface (GUI) of the POS plays an important role in usability since factors like ease of use, intuitiveness and flexibility can considerably affect user performance and productivity.

POS Podium Cash Drawer

Figure 9 POS podium cash drawer

This cash drawer is positioned to allow face to face orientation with the customer. In addition to enhancing customer contact, this orientation also reduces twisting. The

vendor claims that it increases productivity by saving up to 5 seconds on each payment transaction. It also eliminates the need for a side counter and saves space for increased merchandising.

Pay-By-Touch Systems

Figure 10 Pay by touch system

Pay-By-Touch Systems enable customers to pay for goods and services with a swipe of their finger on a biometric sensor. It allowed secure access to checking, credit card, loyalty, and other personal information, through the unique characteristics of an individual's biometric features, thereby creating a highly secure anti-identity theft platform.

Bi-optic Scanners

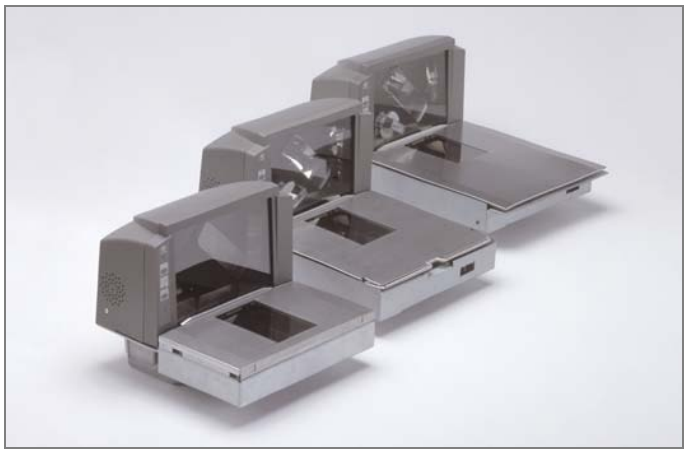

Figure 11 Bi-optic bed scanners

Bi-optic scanners consist of both horizontal and vertical windows that can read barcodes on four or five sides of a product, thereby reducing the need to reorient the barcode toward the scanner. Bi-optic scanners have been shown to reduce wrist accelerations, lifting, and awkward postures compared with traditional single-window scanners.

Key Findings and Implications for a Universal Design Retail Checkout Workstation

Current checkstands found in the U.S only accommodate standing users. Their main differences were in POS placement and bagging system. Because lifting was identified as one of the main factors of injury while bagging items, a further study of the benefits from these different bagging solutions should be performed involving experienced users. On the other hand an overview of the available self- checkouts didn't show much difference between each other. Main differences were about size and component distribution in less extend. Self checkouts evaluation Self-checkouts overview raise design implications rewarding component placement as the key usability issue. Also

the drivers of why some customers prefer self-checkouts from cashier checkouts should be study in further detail as well as the affordances for people with functional limitations. Some technologies reviewed and described in this section showed a great potential to addressed universal design goals of this project. One example is the smart scale from IBM. This type of technology can aid the cashier as well as the customer during the weighing of produce. Because it uses image recognition technology to identify produce, it eliminates the need to remember codes or look for the specific item in a list or menu. In this way, cognitive demands like memory and identification abilities are reduced and thus are job barriers. Another technology that offers great potential is the touch screen. Touch screens as the main input device for cashiers offers a wide range of possibilities rewarding user interface and checkout tools. With the use of touch screens, for example, a more suitable visual interface could be provided to cashiers with low vision as well as other software tools that improve usability and productivity. Other technologies like the handheld scanners allow the customer or the cashier to scan items without lifting them or taking them out of the shopping cart.

Future of Retail Checkout

As technological innovation, globalization, and other factors increase their pace of change, a deep look into their drivers and impacts on our lives becomes increasingly important when designing a checkout system with a compelling value proposition. This section covers an overview of the different technologies and trends that promise to change the future of retail checkout.

RFID

One technology, which may impact cashier's task and employment, is radio frequency identification (RFID). RFID is an identification technology that uses wireless readers to access data encoded in chips. The chip is provided with an antenna, which receives radio frequency signals from the read/write device and together forms what is commonly known as a transponder or tag. The tag can be attached to a label or other form factor, such as a wristband, and the result is referred to smart media that can be then attached to an object and carry all kinds of data about that object (Zebra, 2007).

RFID technology allows universal product codes (UPC) to be replaced with microchips on individual items, opening a large range of possibilities like allowing entire shopping carts to be instantaneously scanned. This can fully automate the checkout process. Because of this potential to dramatically impact the retail industry, it is important to look at the current level of implementation, its timelines and factors involved.

A study in the adoption rate of RFID technologies in the retail industry done by Retail Systems Alert and sponsored by NCR showed that it is slowly beginning to move beyond the command of major retailers, however there are still several technological and organizational issues responsible for the slow pace of this (Kilcourse, 2006). The main key benefit that manufacturers and retailers are focused on is on "Supply Chain Integrity" (Kilcourse, 2006). The supply chain is the system of organizations, people, technology, activities, information and resources involved in moving a product or service from supplier to customer (Wikipedia, 2007). On one hand, manufacturers expect to improve on-shelf position and reduce safety stock by RFID implementation. Retailers, on the other hand, are more focused on human error reductions. The study reports that 44 percent of

manufacturers have developed a timeline of implementation for the next five years, while only 9 percent of the retailers reported to have one.

The current RFID adoption lays on a narrow set of high-value product lines and working on the fundamental issue of Traceability (tracking information about every step in the supply chain process) and Supply Chain Integrity (Kilcourse, 2006). That means that companies are focusing their attention on one to fifty valuable product lines in which the relation of investment and the value of the merchandise is favorable and return of investment is expected, rather than across a broader range of product lines. Also, the use of RFID is happening at a pallet / case level just for supply chain traceability and not at item level tagging. Right now, it is not financially viable for any company to implement RFID in all of the individual items of their product lines given tag prices of $0.15 – $0.25 (GMA, 2004). Analysts imply that tag prices must be approximately $.01 for all companies to implement RFID tags. It is unclear whether tag manufacturers can offer lower priced tags within the next five to seven years.

Many challenges, both technical and cultural, continue to impede the growth of RFID. Technical challenges include poor read rates and interference from other wireless devices, trouble affixing RFID tags to their products, and consensus and maturity of RFID standards (Zebra, 2006). Cultural challenges deals with security issues like legitimate readers getting information from illegitimate tags, whereas privacy issues deal with illegitimate readers getting information from legitimate tags (Agarwa & Mitra, 2006). While the use of RFID increases security in some areas, the very nature of RFID communication poses a number of new privacy and security risks. These security and privacy concerns among the population are very common when new technologies of this

nature are introduced because the negative implications of unauthorized access to information that RFID technology can provide. However, these concerns tend to disappear over time and with the implementation of better legislation and improved technology. A similar case happened with the introduction of online shopping in the past decade.

Self service technology

Consumers today are taking advantage of an increasing number of self-service options that add convenience to their daily lives, from pay at the pump gas stations, to self check in kiosks at the airport, to drive through automated teller machines (ATMs). In retail checkout, this technology is gaining acceptance as well. Consumers are demanding engaging self-service options, and retailers are implementing it because these technologies can produce valuable advantages for a business's bottom line (IBM, 2008). Also trends like Mini shopping, which is the phenomenon of consumers making frequent visits to stores each week to buy a few items as a result of the desire to buy fresh foods and time pressures on people's lives, promotes the implementation of self checkout technology due to the improved overall checkout time. In fact, a study done by NCR Corporation found that the majority of shoppers would choose a store that offered self-service over one that did not (NCR, 2006). In addition to a faster checkout experience, self checkout solutions are designed also to provide better customer service by adding more open lanes, which help shorten lines and improve labor utilization. However, many self checkout applications fail to deliver these benefits, because either they do not provide a positive experience for the customers, or these solutions can be difficult to customize or scale as retail stores needs change. In particular, solutions based on a closed or

proprietary architecture can be challenging to upgrade and may require frequent interaction with the software vendor (IBM, 2008).

Metro future store initiative

The future of retailing is the core topic addressed by the METRO Group Future Store Initiative (Metro Group, n.d). The goal is to promote innovation and develop benefit-oriented forward-looking yet feasible technologies in practical tests, which offer advantages to customers, retail stores, and to the consumer goods industry. Consumer expectations have changed a great deal in recent years. Up to now, the retailing sector has implemented new technologies only in the form of individual applications or isolated systems, whereas in the Future Store, various modern technologies are linked together in complex ways for the first time ever. The METRO Group's Future Store initiative includes the use of RFID or smart chips, Self Check-outs, smart scales and Personal Shopping Assistants (PSA). These systems make the payment process more efficient and lead to shorter waiting times.

Key Findings and Implications for a Universal Design Retail Checkout Workstation

The overview of current technologies and trends that promise to dramatically change the future shopping experience provided valuable insights about the near future scenario of retail checkout. RFID technology at the front end promises to eliminate long checkout lines, mitigate shoplifting, and allow more customers to move through the store more quickly. But the implementation at the front end of supermarkets has been almost nonexistent. Also, it is important to point out that the most representative RFID projects

at the supply chain level to date have been under a mandate from a large retailer like Wal-Mart and Tesco and not necessarily because they needed it. Manufacturers are ahead of retailers in RFID implementation, but their focus is in the back end, logistics and inventory that includes cases, totes and pallets but not item level tagging. While some people claim that RFID technology makes good business sense, actual RFID adoption in the real world has, thus far, been marked by failure (Tedjasaputra, 2005). Adi Tedjasaputra, founder of the RFID community in Asia, states that companies thinking of RFID as merely a form of next-generation barcode technology are one step closer to its failure upon adoption (2005). He states that companies that focus on selling "experiences" instead of services will find RFID and other technologies like self checkout as a window of opportunity to provide better shopping experiences for customers, and thus improve the company bottom's line. However, real applications of these technologies, would initially appear only at larger supermarkets due to the cost and organizational integration issues, and it is still years away from being implemented. On the bright side, these technologies may provide new employment opportunities for people with disabilities in the future, because these technologies aid or eliminate tasks that were previously limiting factors such as scanning.

Self-checkout proved to be the technology that is currently generating more impact at the retail frond end and with increasingly rate of adoption over the next years. However, key issues about this technology failing to provide positive experiences to customers were pointed out. Self checkout technology may offer considerable benefits to a group of shoppers looking for faster checkout times, nevertheless there are still a significant amount of challenges that this technology cannot overcome. As a conclusion,

a further analysis of the benefits from the cashier checkout and self checkout should be addressed with casual observations and participatory research. The bottom line of this section is that self checkout and cashier checkout are going to coexist at the retail front end for the next 5 to 10 years, and thus any design proposition with value into the future should provide the benefits offered by both types of checkout.

Design Parameters

After gathering and analyzing the relevant findings and information rewarding the universal design of grocery retail checkouts, a design parameters list was compiled. This served as the main framework for designing the preliminary concepts. Following this set of guidelines should provide a more accessible and comfortable checkout workstation that maximizes independence and participation of diverse individuals as well as reduces work related injuries.

Work Surface Height:

Determining work surface height for a grocery retail checkout workstation is not an easy task. Grocery retail checkstands have two end users, each in a different context and from a very diverse population. One end user is the employee and the other is the customer. Cashiers play a more important role than customers in checkout workstation design because cashiers interaction with the workstation ranges from 4 to 8 hours per day while customers interaction with it, is just about a few minutes and once in a while, so more compromises can be made for the customer side than for the employee side. But that doesn’t mean that customer requirements should not be considered.

The grocery retail checkstand's surface height adjustability range should be within a common frame between employees and customers performance envelopes. Performance envelops may vary depending on anthropometric variables and working positions. The universal design approach of this project imposes accessibility requirements for standing, seated and wheelchair users.

Criteria:

The standing and wheelchair users represent the extremes of the critical functional requirements for workstations.

"For retail workstations, optimum work surface height and peripheral component location become relative to the individual user's performance envelop. Since these measurements would vary greatly from user to user, the ideal workstation would allow for adjustment or modification" (Ringholz, 2006).

Range:

The lowest extent for an adjustable work surface would be 65.8 cm for the 5th female percentile manual wheelchair user and the highest would be 111.7 cm for the 99th percentile male standing user.

The range of work surface adjustability was determined by identifying the extremes of the critical functional requirements among the following users:

Table 2performance Envelop

PERFORMANCE ENVELOP		
User	**Lowest Extreme**	**Highest Extreme**
Standing Customer	1st percentile female performance envelop (Dreyfuss, 2002): • Shoulder height: 118.6 cm • Finger tip height: 55.6 cm	99th percentile male performance envelop (Dreyfuss, 2002): • Shoulder height: 159 cm • Fingertip height: 75.1 cm
Standing Employee	1st percentile female performance envelop (Dreyfuss, 2002): • Shoulder height: 118.6 cm • Elbow height: 92.5 cm • Recommended work surface is 10 – 15 cm below elbow height	99th percentile male performance envelop (Dreyfuss, 2002): • Shoulder height: 159 cm • Elbow height: 121.7 cm • Recommended work surface is 10 – 15 cm below elbow height
Seated non disabled employee	1st percentile female performance envelop (Dreyfuss, 2002): • Shoulder height: 90.9 cm • Elbow height: 59 cm • Recommended work surface is +/- 2.5 cm elbow height	99th percentile male performance envelop (Dreyfuss, 2002): • Shoulder height: 116.9 cm • Elbow height: 75.8 cm • Recommended work surface is +/- 2.5 cm elbow height
Wheelchair user employee	1st percentile female performance envelop (Paquet, Feathers, 2004): • Acromion (Shoulder) height: 88.6 cm • Elbow rest height: 65.8cm • Recommended work surface is +/- 2.5 cm elbow height	95th percentile male performance envelop (Paquet, Feathers, 2004): • Acromion (Shoulder) height: 120.3 cm • Elbow rest height: 85.1 cm • Recommended work surface is +/- 2.5 cm elbow height

The lowest work surface height from the *customer's* point of view is 75 cm corresponding to lowest extreme of the customer performance envelop. From the *employee*'s point of view the lowest work surface height is 59 cm for the seated 1^{st} percentile adult females. However, a work surface at this height is too low for the standing customer whose performance envelop ranges from 75 cm finger tip height for the 99^{th} percentile males to 118 cm shoulder height for 1^{th} percentile female. Wheelchair user's performance envelop lowest extreme is 65.8 cm which is also out of the performance envelop of the standing customer. While for the seated user is easy to provide a solution to overcome this gap with an adjustable chair and a footrest, for the wheelchair user is not, therefore the wheelchair user becomes the lowest extreme of the critical functional requirements for work surface height even though, it represents a compromise for the highest percentile male standing customers.

Component Placement

Criteria

Standing users have the farthest reach, while wheelchair users have the shortest reach. Maximum reach is obtained for all standing and seated individuals at 30cm above the work surface (Sengupta, Das, 2000). Standing workers have the highest line of sight, while wheelchair users have the lowest line of sight (Dreyfuss, 2002).

The normal reach is defined by the tip of the thumb while the forearm moves in a circular motion on the table surface (Sengupta, Das, 2000). For performing repetitive tasks, the hand movement should preferably be confined within the normal working area (Sengupta, Das, 2000). The maximum reach can be considered as the boundary on the work surface in front of an operator to which he/she can reach without flexing his/her

torso (Sengupta, Das, 2000). The controls and items of occasional use may be placed beyond the normal working area, but within the maximum working area (Sengupta, Das, 2000). Reaching beyond the maximum working area will cause the torso to be flexed. A repetition of such posture may lead eventually to lower back pain (Sengupta, Das, 2000).

Range

Peripheral workstation components should be placed no higher than 30cm from the work surface (Dreyfuss, 2002). The scanning system should be within the normal reach distance. Other components should be within the maximum reach distance of 5th percentile seated females, or 62.5 cm (Sengupta, Das, 2000). For comfortable viewing, all displays should be located no more than 30 degrees above and 30 degrees below the user's line of sight. (Dreyfuss, 2002).

- The Maximum Reach Envelop for standing individuals without a disability at 0 degrees is between 67.1cm and 84.3cm for 5^{th} to 95^{th} percentile females, and between 75.4cm and 88.4cm for males (Sengupta, Das, 2000).
- The Maximum Reach Envelop for seated individuals without a disability at 0 degrees is between 62.5cm and 80.3cm for 5^{th} to 95^{th} percentile females, and between 69.8cm and 87.0cm for males (Sengupta, Das, 2000).
- Forward approach for wheelchair users is (Dreyfuss, 2002):
    - High: 48" (121.9 cm) from floor
    - Low: 15" (38 cm) from floor
- Eye height for standing, non-disabled individuals ranges from 138.9cm to162.8cm for 5^{th} to 95^{th} percentile females, and 151.4cm to 176cm for males (Diffrient, 1993.)

- Eye height for seated, non-disabled individuals is between 104.4cm and 122.1cm for 5th to 95th percentile females, and 113.5cm and 132.3cm for males (Diffrient, 1993.)
- Eye height for wheelchair users ranges from 92.9cm to 130.7cm for 5th to 95th percentile females, and 98.7cm to 140.5cm for males (Das, Kozey, 1999.)

Codes & Standards

- "Place in-feed conveyor belts as close as possible to the cashier to minimize reaching" (OSHA, 2004)
- "Remove, round-off, or pad sharp or hard edges with which the cashier may come into contact" (OSHA, 2004)
- "Provide adequate toe space (at least 4 inches) at the bottom of the workstation. Toe space allows cashiers to move closer to the checkstand, decreasing reaching requirements" (OSHA, 2004)
- "Use footrests and anti-fatigue mats in areas where workers stand for prolonged periods. Standing on anti-fatigue mats, as compared to bare floors, provides a noticeable improvement in comfort" (OSHA, 2004)
- "Provide a technology to enter the quantity of identical products rather than scanning each individual item" (OSHA, 2004)
- "Place keyboards on supports that adjust in height, horizontal distance and tilt to keep work within the preferred work zone" (OSHA, 2004)
- "Use front facing checkstands to reduce twisting motions and extended reaches to the side" (OSHA, 2004)

- "Provide scan guns for large or bulky items to eliminate the need to handle them" (OSHA, 2004)
- "Set scanners and conveyors at the same height so that cashiers can slide items across rather than lift them" (OSHA, 2004)
- "Tops of plastic bags should be just below conveyor height" (OSHA, 2004)
- Provide a minimum 30" x 48" for clear floor space for wheelchair forward approach (Dreyfuss, 2002), (ADA).
- Provide a minimum 68.5cm knee clearance for wheelchair users (Dreyfuss, 2002), (ADA).

Other recommendations / Guidelines

- Provide efficient ways to tell people that checkstands are open for customers – people tend to get piled up at the first few isles (Quick, 2006).
- If LCD screens are used, make sure they have a wide viewing angle (Quick, 2006).
- A checkstand offering both options of sit and-scan and stand-and-scan would provide the greatest relief from fatigue, because cashiers would be able to alter their positions frequently (NCR, 2001)
- Components of the checkstand should leave enough clearance for large items (Quick, 2006).
- Cashiers facing each other have better communication and are more likely to help each other – because they are more aware of the needs of the other employee (Quick, 2006).

CHAPTER 3

RESEARCH METHODOLOGY

After evaluating this information and the literature review, it was evident that qualitative data was needed in more specific areas such as employee's experience with carousel bagging checkstands and self-checkouts, attitude toward assisted and self service and employee feedback about future checkout concepts. With this in mind, several qualitative research methods were planned to gather information and insights about those missing areas.

Brainstorming

Brainstorming is a group technique designed to generate a large number of ideas that might provide new directions to a solution of a problem. This type of technique is usually focused on quantity with the assumption that the greater the number of ideas generated, the greater the chance of producing new radical and effective possibilities. However the ideas will probably need further exploration and evaluation. Through this technique divergent thinking is encouraged where unusual ideas are welcome and criticism should be reserved supporting an atmosphere where participants feel free to generate unusual ideas.

A brainstorming session was used to explore participant's expectations of their ideal retail checkout. The session was structured into three different activities conducted by a group of five people. The figure below illustrates the strategy used to guide the participants into the topic.

Figure 12 Brainstorming strategy

1st Activity

Description: Five participants from the graduate thesis studio including our professors were asked spend15 minutes listing activities with which they like to have assistance or have done by other person. Later, they were asked to list activities they like to do alone, without any assistance.

The purpose of this activity was to warm up the group and introduce the foundation of assisted and self checkout. Another objective was to learn about related terms, actions or desires of participant's preferences. This might provide additional information about the reasons why people prefer either self checkout or assisted checkout.

2nd Activity

During this activity participants were asked to list what they like or dislike of cashier checkout and self checkout. The main purpose of this activity was to learn about the different drivers that lead customers to use either self checkout or assisted checkout. It was also important to learn about people overall perception and issues of these two type of checkouts. Later on this information can be compared to findings from other study such as casual observations.

Casual Observations

Casual observations at store front ends were conducted by the researcher to become familiar with the retail checkstand work environment and identify issues with current checkstands. Four retail locations in Atlanta were observed and these four locations consisted of one department store, one "Do It Yourself" store and two grocery stores. The main purpose was to identify common cashier activities and demands while working at checkstands found in three different types of retail stores. During observation periods, the researcher stood 15-20 feet away from employees and customers. Notes were recorded on a spreadsheet with cashier tasks in an attempt to categorize the handwritten notes, however, the use of this spreadsheet was usually unsuccessful due to the fast pace of the activity. In order to provide more flexibility, the spreadsheet was changed into two categories, one for cognitive /behavioral activities and the other one for physical/mechanical activities. The observation time was 2 hours for each store visit. Types of checkstand found in the stores where casual observation took place include: scan bag pass, carousel bagging, drop-in bag well and self-checkout.

Group Interviews

To further complement the research with qualitative data, a group study was designed. The purpose of this study was to learn about cashier's issues with common checkstand designs, front end equipment relation to cashier performance as well as cashier's ideas for checkstand design improvement. A combination of semi-structured group interviews with worksheets for the participants was the tool used for this study. The semi-structured interviews are suitable for obtaining in depth information with the flexibility of re-arranging the order, changing the wording or sentence structure to better fit the participant or the situation (Sommer and Sommer 2002). The worksheet served as a guide into the different topics as well as a tool for the participant to write their insights and comments. The researcher guided the group session through a series of concrete questions for each section with some other questions in-between that helped to get more in-depth information. At the end of each section, participants were encouraged to describe and sketch areas for improvement for the current and future checkstand designs. The group interview was initially planned as a onetime session but difficulties with the recruitment forced the researcher to do two sessions with smaller number of participants. Each session lasted approximately one and half hours. Audio recordings and notes were captured.

Recruiting

Recruitment was done through flyers and in-store personal requests. Store managers often stated that their policy was not to allow any type of outside study from

the company. Other difficulties were cashier's time availability and transportation issues. A total of 6 participants were recruited, 4 for the first session and 2 for the last session.

Subjects

- have cashier experience
- Between the ages of 18 and 65
- Wheelchair users
- People with low vision impairment
- elderly

Protocol

After signing the required consent forms, participants were greeted and introduced to the study. Then poster images of four different types of checkstands were shown including scan pass bag, drop-in bag well, carousel bagging and self-checkout checkstands (see figure 17). For the first section, participants were asked to use their experience as a cashier to comment on and discuss the strengths and flaws of these types of checkstands and suggest improvements.

Specifically, they were asked:

- What are the strengths and flaws of these current retail checkstands?
- What features hinder /help the following retail checkout tasks?

  (Scanning Items, Code Lookup, Screen Interaction, Payment process, Bagging, Receipt Handling, Storage, Cleanliness)
- What are your suggestions of design improvements?

During the second part, participants were asked to comment about two different future hybrid-checkout concepts (see Figure 18), presented in short videos. After participants discussed the strengths and flaws of the future retail concepts, they were asked to write or draw suggestions of design improvements for these future checkstand concepts. After the two sections had been completed, the researcher asked to mark with three sticky dots provided, the three most important insights or suggestions they expressed during the whole session.

Protocol

1. Participants were asked to fill a questionnaire of demographic information.
2. Pictures of current grocery retail checkstands were shown to the participants and the following questions were asked about them. (fig 16)

- What are the strengths and flaws of these current retail checkstands
- What hinder /help the following retail checkout tasks
  (*Scanning Items, Code Lookup, Screen Interaction, Payment process, Bagging, Receipt Handling, Storage, Cleanliness)*
- What are your suggestions of design improvements

3. A short video introducing the concept of the *hybrid-checkout* was shown followed by a detailed presentation of the two future retail checkout concepts (fig 17). Then the following questions were asked to the participants.

- What are the strengths and flaws of these current retail checkstands
- What are your suggestions of design improvements

Figure 13 Types of Checkstands

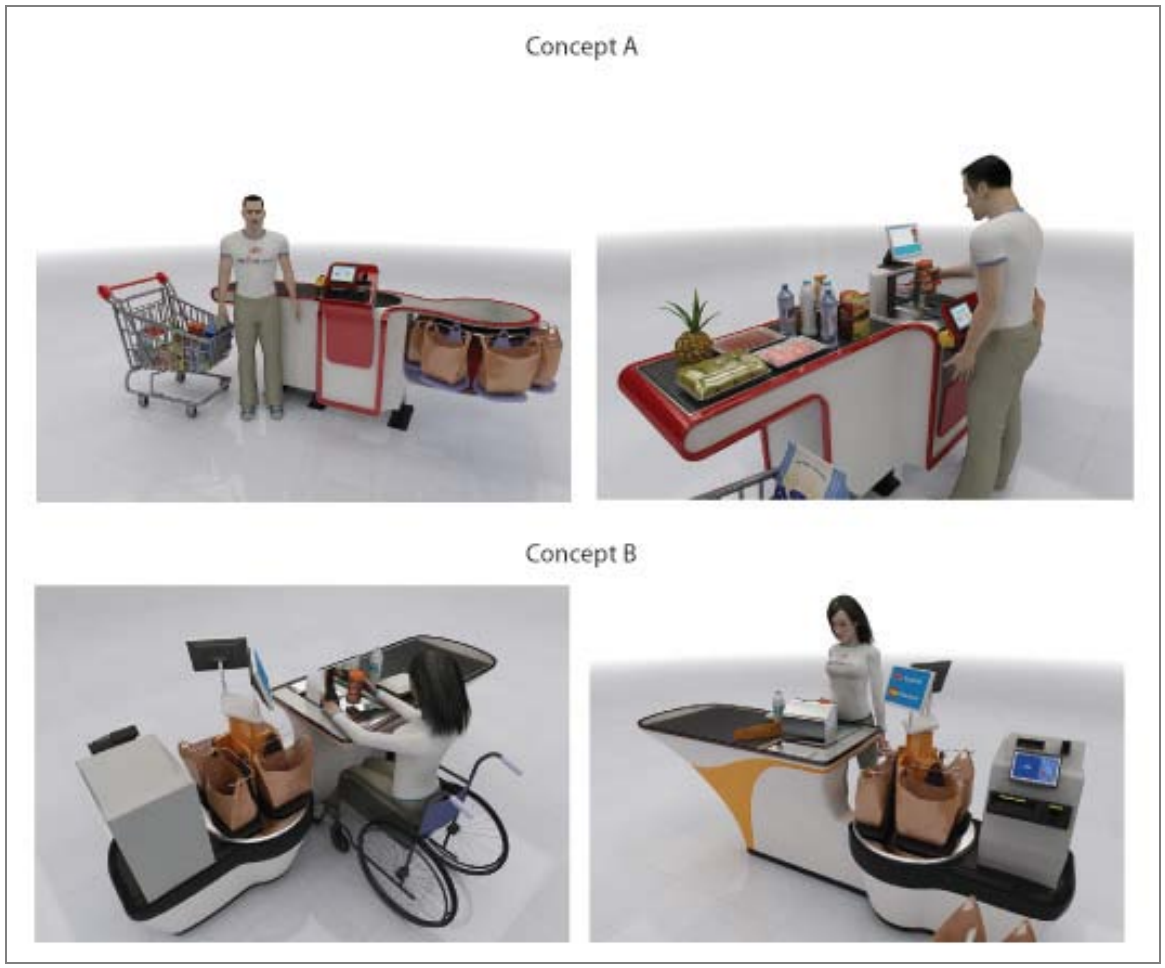

Figure 14 Future Checkstand Concepts

CHAPTER 4

RESULTS

Brainstorming

1st Activity Summary of findings:

Table 3 1st Activity Summary of findings

Assisted Preferences	Non assisted Preferences
• Information needed • Luxury • Safe / dangerous • Fear doing it wrong • Difficult to do • Physical limits • Time consuming • Hate cleaning • Boring not challenging • Likes to have company • Repetitive actions • Things that need to be supervise	• Doing at your own pace • Privacy required / desired • No people judging you • Fun, creative and challenging activities • Involves pleasure • Enjoyable • Personal • Need to have control over it • Takes time to analyze information • Things related with money • Needs to be careful • Things that are going to be eaten • No people rushing you

2nd Activity Summary of findings:

Table 4 2nd Activity Summary of findings:

Cashier checkout	
Positive Comments	**Negative Comments**
• Efficient most of the time • Nice to chat with clerk • Like to see the magazines while waiting in line • Used when items need to be weighed • Payment fast • Not taking care of bagging • Cashiers are fast	• Wait in line • Slow • Depends on Cashier mood (3) • Low control • time consuming • Difficult to fit everything on the belt (2) • Hands feel dirty - dirty belt • Stressed when no divider available • Delicate things handling • Crowed • Long lines • Guessing fast lines
Self-checkout	
Positive Comments	**Negative Comments**

• Fun to use the scanner • Feels faster • Lines are shorter	• Malfunction machine • Lifting items (2) • Can be slow • Stressful • lack of social interaction • Bad bagging • Poor payment method • Waiting for employee / assistance (2) • Not enough area for bagging (2) • Long wait / Time consuming(2) • Confusing (2) • Instructions are not enough • Bags never seem adequate • placement of bags is awkward • Won't ever use cash • Hard to scan the loyalty card • Don't like to scan large or many items • Too many errors • Never used when items need to be weighed • Waiting for ID check • Not as fast as a professional cashier • Hard to redeem coupons

Casual Observations

Table 5 Casual Observations

Casual Observations	
Cognitive / behavioral	**Physical / Mechanical**
• Cashiers lean constantly on the counter while they are not busy • Cashiers checkouts are usually much faster than self-checkouts • Cashiers checkouts are usually much faster than self-checkouts • All of the observed customers of self checkout had few items • cashiers stand during shifts with no apparent place to sit • Noisy environment (people talking, scanner beeps, announcements, etc)	• Checkstands lack enough space to put large items after being scanned • Carousel offers an efficient way to bag items when there's not a high quantity of items • Carousel offers an efficient way to bag items when there's not a high quantity of items • Retractable shelf for wheelchair users were never used, however, only a few wheelchair users were observed • Checkstand with one shared display didn't offer a proper viewing for either the cashier or customer • Cash drawer is usually by one side of the cashier which forces twisting of the trunk • Continuous turning for pulling out receipt or bagging • grip strength is required for constantly lifting bags • Significant counter space occupied by retail items

Group Interview results

Strengths and flaws of: Scan -Pass-Bag / Belt out feed

Figure 15 Scan -Pass-Bag / Belt out feed

Table 6 Strengths & Flaws

Strengths	Flaws
• Smooth and fast process flow • Helps customer go through easily • Large counter space area • Multiple belts provides more efficiency • Take away belt is sometimes very useful • Quicker scanning process	• Requires usually two employees; cashier and bagger • Items pile up quickly, bagger have to keep a very fast pace • Customers can load up too many items • Bagging area not visible • Cashier has to do all the bagging

Strengths and flaws of: Drop in bag well

Figure 16 Drop in bag well

Table 7 Strengths & Flaws

Strengths	Flaws
• Less strain for cashiers: less lifting • Takes up less space than other type of checkstands • Quick for customers • Items can be put very easily into the bags • Bagging directly after scanning is very efficient • Works for few items purchase	• Large item represent an issue. Lack of counter space • Not enough space for bagging • Too small, not comfortable • Time consuming because of limited bagging stands • Reduced bagging area • For large purchases doesn't work

Strengths and flaws of: Carousel Bagging

Figure 17 Carousel Bagging

Table 8 Strengths & Flaws

Strengths	Flaws
• Customer is forced to participate • Fast bagging • Can easily go back to a bag and put more items • Allows the direct scan to bag method with the benefit of multiple bag stands	• Is likely that customers left behind bags • Mixed up bags with other customers • Conveyor belt area too small • Not too many items can be put over the carousel. Only one size of bags • Can't control the spinning • Cashier cannot place items directly into customers cart

Strengths and flaws of: Self Checkout

Figure 18 Self Checkout

Table 9 Strengths & Flaws

Strengths	Flaws
• Quick checkout • Good for customers with few items • less workers needed • Shorter lines • Eliminates multiple employees	• Customer errors • It malfunctions frequently • Small bagging area • Erratic performance • Security weigh scale very sensitive. Source of most problems with customers • Customers are more prone to error than a trained cashier

What hinder /help the following retail checkout tasks

Table 10 Hinder / Help

Helps	Hinder
Scanning Items:	

• Increase counter space after scanner • Scanner bed and scanner gun • Handheld scanner • Design minimizes lifting • Redundancy in bar codes, several bar codes on the item	• Reduced space to place items • Customer decide to put items back • Not enough space for large items to be scanned
Code Lookup:	
• Computer base catalog system • Incorporated at the register • List with pictures	• Waiting for someone to search the item
Screen Interaction:	
• Touch screen • Large icons • Viewable by cashier and customer • Customers can see precise information of the scanning and payment process • Simple and direct commands	• Non interactive – user friendly system like ms dos • Only one screen
Payment process:	
• Card scan systems • Registers calculating the change • Customer able to do it by themselves • Credit card payments are definitely faster than cash • Customer selects the type of payment before cashier finish scanning	• Count back change • Having to call card company to get approved someone cards • Cashier have to key it in • Difficulty reading cards • Money not accepted by cash in slots • Changing payment types are not easy
Bagging:	
• Carousel	• Bags sticking together

• Bag immediately after scanning • Encourage customers to participate	• Bagging system visibility
Receipt Handling:	
• Automatic print out • Receipts prints toward customer	• No out of paper roll indicator • Receipts prints at the end and customer already has their hands full
Storage:	
• Get rid of unnecessary storage space • Small but easy to reach storage space	• Too much storage compartments
Cleanliness:	
• Moisture absorbent conveyor belt • Self cleaning belt • Trash compartment	Small area for unwanted items

Suggestions of design improvements for current checkouts:

- Adequate knee space so a wheelchair user can work facing the customer
- Self-cleaning belt will reduce the time spend by cashiers cleaning it
- Incorporate a big screen that customer and cashier can shared
- Carousel system with more bag stands
- Bags that don't stick together
- Checkstands should have a space reserved for items that customers decided not to buy
- Provide bag stands by the side of the customer to encourage them to participate
- Checkstands for seated working positions

- Bagging and shopping cart system that puts the bags inside the cart automatically

Strengths and flaws of: Hybrid Checkout concept A

Figure 19 Hybrid Checkout concept A

Table 11 Strengths & Flaws

Strengths	Flaws
• Quick transformation into cashier checkout • Carousel top counter space • Wheelchair accessibility • Adapts to situations with few and many items • Items are easy to reach for scanning • Height adjustability • Function for calling assistance	• Conveyor belt slows down process, items must be handled twice • Bagging system needs more than one size of bags • Reduced visibility of the carousel may increase items left from customers • Needs more bags

Strengths and flaws of: Hybrid Checkout concept B

Figure 20 Hybrid Checkout concept B

Table 12 Strengths & Flaws

Strengths	Flaws
• Overall size of the checkstand • Ability to work with or without cashier • Increased accessibility • Payment systems grouped at the end of the checkstand • Transformation system of the scanner • Customer totally in charge of payment system. No complains about the change • Wide conveyor belt • Easy for cashier to approach for assistance	• Lack of carousel counter top • Multiple placement of items • Reduced space for bagging items • Carousel too small • No room for large items

Participants were asked to use the three sticky dots provided to point out the three most important insights or suggestions they expressed during the whole session. The following is the list of their selected insights.

- Customer totally in charge of payment system. No complains about the change
- Top counter space over carousel for scanned items that are not bagged (3)
- Scanning and bagging systems that reduce lifting of items
- More reliable and user friendly self checkout systems to reduce customer errors and complains
- Incorporate handheld scanners for customers (2)
- Reduced workload for the cashier in the hybrid – checkout system
- Checkstand that encourage customer to participate in the checkout process
- Reduce unnecessary storage to make more room for the cashier
- Hybrid checkout provides a more efficient use of human and technical resources
- Erratic performance from self checkout technology creates overload to self checkout cashiers and hinders the overall purpose of self checkout that is speed
- Checkstands should have a space reserved for items that customers decided not to buy
- Weigh scale security system in self checkouts should be improved or eliminated. Causes more problems than the ones it solves
- Carousel checkstands allow the direct scan- bag method with the benefit of multiple bag stands
- Self checkout mode don't need conveyor belt. It slows down the checkout process because items must be handled twice

CHAPTER 5

DISCUSSION

Brainstorming

1st Activity

Participants preferred assisted activities were described as activities that are boring or does not represent any challenge or satisfaction such as cleaning, driving or doing laundry. Also activities that participants fear of doing it wrong were among the preferred assisted activities. Reasons behind this are because they are not familiar with them, they raise safety concerns or they are simply hard to do. In general, most of the activities chosen for this category, were activities considered mundane with very little satisfying or fulfilling outcomes and activities that without assistance might be very time consuming. In the retail checkout context, tasks like scanning and bagging large quantity of items could be considered boring and unsatisfying. In this case cashier checkouts should be adequate for this kind of situations and a point of interest to analyze with the casual observations.

Non assisted activities preferred by participants include activities that require privacy like bathing, dressing and other personal intimate activities. Other activities preferred in this category were activities described as challenging/interesting or fun/enjoyable like cooking a special meal or shopping for highly desired items. Finally other activities chosen for this category were activities that participants preferred doing it at their own pace with no pressures. Translating these results into the retail checkout context several insights can be deduce. Checkout tasks like scanning and bagging large

quantity of items might be considered boring and time consuming. People presumably would like these tasks done by a trained cashier rather than themselves. However, people that like to have everything under control might feel better if they do it by themselves. Based on these findings, self checkout systems might be appealing to people, who prefer doing things at their own pace or seeks a more private transaction when purchasing products that are considered intimate or embarrassing.

2nd Activity

Not surprisingly, participants focused more in the negative aspects of both cashier checkouts and self checkouts rather than the positive aspects. This might be because people tend to notice the things that don't work while the ones that work usually are imperceptible. Cashier checkout received overall less negative comments than self-checkout. The following list is a summary of the main findings during this activity.

Cashier checkout:

- Social interaction is one of the main reasons to look for a cashier checkout
- Assistance is desired when items need to be weighed, are large or too many
- Payment processing is considered to be fast
- Cashier's mood has a an important impact in user experience
- Participants expressed their belief that they are always crowed

Self-checkout:

- People have the belief that self-checkout is fast but is not always the case and cause more frustration
- Ease of use seems to be the main problem with these type of systems
- Assistance is usually slow to get

- Never used when items need to be weighed of they are too large to use

One key aspect to point out is the social interaction that offers the cashier checkout. I belief the human factor is in fact one of the main reasons cashier checkouts won't be replaced by self checkouts. Human beings are social entities by nature and grocery stores are public places were social interaction is likely to happen. This activity proved to be a source of possible key issues that served as a guide for the casual observations.

Casual Observations

Through this study several hypothesis about key issues and people behavior towards assisted and self checkout were validated or prove wrong. The observations

- Cashiers performed constant and repetitive lifting actions. At locations with belt outfeed checkstands, cashiers had to do a greater effort during bagging while observed cashiers at locations with carousel bagging checkstands, cashiers performed less lifting because they don't have to hand the bags to the customer. This type of bagging system was identified as the most efficient of all types of bagging observed. However, the lack of countertop space was a disadvantage for customers that were checking out large items. It was also observed that this type of system provides the greatest accessibility for wheelchair users. They could easily rotate carousel and reach for all the bags. This type of bagging systems proved to have the greatest potential for implementation in a universal designed checkstand. A bagging system that minimizes lifting and bending could reduce job barriers for people with low mobility impairments.

- Limited accessible features for wheelchair users were identified. The most common aid for wheelchair users was the retractable shelf but was barely used. This retractable shelf provides limited benefits and design and usability should be improved. A retractable pin pad with an integrated shelf should prove to be more useful and provide a increased accessibility not only to wheelchair users but other for other population with functional limitation like people with low vision or dexterity problems.
- Self-checkouts were used mainly by customers with few items and most of them without shopping carts. Self-checkout proved to be fast when customers use it to checkout few items and the customers had no problems with it. However, customers required assistance quite often which interrupts the fast flow of customers of this type of checkouts. Based on this evidence inquiring about these issues became an objective for the group interviews. Current self checkouts demands considerable cognitive abilities that could be a barrier for people with this type of disabilities. Preliminary insights about this issue show that a more intuitive workflow and better user interface should be addressed through design and thus accomplish universal design goals.
- Component placement varied from one store to the other but in general it was usually spread out over the checkstand with no relation with the process flow. For example, some checkstands while having the POS system in front of the cashier, the receipt printer location was by one side, forcing the employee to turn or twist. Observations like these were common with no apparent reason behind those design decisions made by the checkstand manufacturer. Checkout workflow and

thus component placement should follow the principle of the path of less resistance.

- Shared displays observed at some stores were usually facing more toward the employee than toward customer, reducing the information and control of the checkout process to the customer. While these checkstands also had a small display that displayed the total amount, it is not enough information for certain customers that lean over the checkstand to see the bigger screen. Front facing checkstands should not have shared displays because the cashier and the customer are facing in opposite directions. Separate displays should be provided for the cashier and the customer.
- It was often observed customers chit chatting with the cashier which proves the social interaction factor of assisted checkouts pointed out during the brainstorming session.

Group Interviews

The overall result from the group session was positive. While many findings and insights obtain from the group interview served to confirmed and validate information gathered with the casual observations or previous studies, there were a small amount but very valuable insights and ideas that helped identify important customer and employee needs. By incorporating these findings into the design framework and process, gaps in the literature and field research were filled and provided interesting insights and practical solutions to common problems and needs of employees and customers. Filtering of data used for checkstand recommendations gathered from participants written insights,

discussion comments and notes taken by the researcher was done by analyzing how it would help to achieve project goals like employee injury reduction, overall accessibility, improvement of interactions and process efficiency.

Future concepts recommendations

Participants showed great interest in the concept of hybrid checkout and they all agreed the hybrid checkout concept have real benefits to the employees, customers and corporate management. The following are the main checkstand design recommendations obtained from this study:

- Carousel system should be provided with a counter top space for large items. A combination of the counter space provided in the concept A with the design and placement of concept B were the participant's main insight about this issue. Casual observations also showed this issue as the main flaw of cashier checkout.
- Counter top space should not block visibility to bag stands, so customers don't leave behind bags. While the counter top space provides a solution for large items it also creates a problem of visibility to the bag stands. If customers often leave bags in current carousel systems without this counter top space, providing this surface over the carousel will reduce even more the visibility and customers will likely forget more often their bags. Participants also shared an insightful solution to this problem. They pointed out that that the weigh sensors under the bag stands could provide an to the customer or the cashier if the customer is leaving without one or more of the bags.
- Handheld scanner for the customer is a very important feature that helps the customer scan large items without taking them out of the cart. With this feature,

the cashier no longer needs to lift heavy items or approach the customer's cart to scan the large items.

- Participants expressed positive comments about concept's payment system, which is facing the customer and uses self checkout technology. This arrangement gives the customer total control over the payment process. The cashier is no longer in charge of the payment process. By handing over this checkout process to the customer, the cashier no longer has the responsibility of counting money or giving change. This will reduce human errors, cashier's job cognitive demands and complaints from customers about change.

CHAPTER 6
FINAL CONCEPT CONSIDERATIONS

Key findings of the studies resulted in a set of proposed features that addresses customer and employee needs. The following is a list of features proposed for the final concept.

- **Work surface** (infeed belt, scanning area and countertop space) height adjustability. Range: 65.8 cm to 112 cm. Description: accommodate standing and seated cashiers.
- **Hybrid Checkout (*Cashiers or Assisted checkout* + *Self checkout*).** Description: provide flexibility and adaptation to several retail checkout circumstances like attending a rise in customers checking out during high peak hours, in this case checkout stations can transform from self –checkout mode to assisted checkout mode and in that way accelerate the checkout process by the help of professional cashiers that should checkout a customer faster. In addition, checkout stations not been attended by cashiers can remain open as a self-checkout station thus increasing the number of lanes open and maximizing the investment of all of these checkout stations.
- **Front facing Checkstand layout:** Description: reduce work related injuries by reducing reaching, twisting, turning, lifting and placing components within optimal reach zones
- **Carousel bagging with countertop space**: Description: provide fast bagging by a rotating system with multiple bag-stands and with similar lifting reduction

benefits like the drop in bag well and height adjustability alongside the work surface.

- **Handheld scanner by the customer side.** Description: provides the customer the possibility to scan large items without taking them out of the cart and are difficult to scan with the bed-scanner. Bright color for easy identification.
- **Receipt printer facing the customer:** Description: eliminate cashier receipt handling. It also provides visual and audible cues like ATM systems.
- **Detachable pin pad.** Description: provides wheelchair and other mobility impaired users the ability to grab and hold closer to their bodies. This will facilitate customer input. Bright color for easy identification.
- **Countertop space.** Description: provides additional space for large items or items that do not need bagging as well as space for customers to put personal belongings like a purse.
- **Customer's bags reminder.** Description: provides visual and audible cues for customers when they are leaving bags in the carousel.
- **Work surface height presets button panel.** Description: provides easy access to work surface heights by storing predefined heights in a panel buttons.
- **Wheelchair accessibility.** Description: provides the clear floor and knee space required for wheelchair accessibility.
- **Smart scanning**. Description: detects when a customer or employee is scanning more than one item of the same kind and immediately prompts the user to input the quantity of the same kind of items rather that scanning all of them.

- **Smart Scale**. Description: incorporates the smart scale technology developed by IBM that recognizes produce using image recognition technology. In this way the employee or customer doesn't have to go search through a list the item or remember a code for the product.
- **Self-service payment system.** Description: self service payment technology is located at the end of the checkstand and facing the customer. In this way the customer is always in charge of the payment process. Also the location at the end of the checkstand allows another customer to start unloading and scanning while the previous customer finishes the payment process.
- **Help button.** Description: provides an easy way to call for assistance in self-checkout mode.

CHAPTER 7

CONCLUSIONS AND FUTURE WORK

From this research, several potential checkstand features which could reduce job demands were identified and proposed and thus increasing employment possibilities by reducing barriers for those with functional limitations. After the analysis of user's performance envelop, workstation height adjustment became a priority since the workforce population measurements would vary greatly from user to user. Features like work surface adjustability for seated and standing cashiers as well as wheelchair users accessibility maximizes independence and participation of diverse individuals and provides optimal accommodation for a constantly shifting workforce. Other features like component placement within an optimal work zone provides a comfortable work environment, reduces work related injuries and physical job demands. In addition other cognitive and physical demands are reduced by translating task like payment processing and receipt handling to the customer.

The universal design guidelines for grocery retail checkstands compiled during this project, not only provide a useful and practical framework for new retail checkout designs but also, serves as an evaluation tool for current checkstand designs. Main goals of universal design such as equitable use and flexibility in use were addressed by providing increased accessibility through accommodations of standing and seated users including wheelchair users. Another aspect of the universal design guidelines is to reduce the physical effort. Task demands and injuries associated with them were analyzed and key factors identified to provide efficient solutions and more comfortable workstation.

Others aspects of universal design like simple and intuitive use were particularly important for the self checkout set up of the checkstand. Eliminating unnecessary complexity found in current self checkouts and the use of other solutions seen in other self service technology like ATMs, provides a more intuitive and consistent interaction with the user. Changes in the retail business driven by social and economical factors generate the need for more universally design products which proven to be the case of the retail checkout industry.

Results from this research showed that addressing users and corporate needs toward a common goal of designing a universally designed future retail checkstand is not an easy task. However, through the implementation of a new checkout concept – "*the hybrid checkout*" – and a set of features that reduces checkout task demands and increase accessibility, the gap between end users and corporate needs can be reduced. With this framework of shared benefits and value, this project intends to create impact in the retail industry by illustrating the potential of universal design and design research addressing the challenges of the near future of retail checkout.

Reducing turnover rates proved to be a major corporate need. While cultural and economic factors like cashier jobs are considered temporary and not a stable career to pursue, and low wages compared to other industries are the main drivers of turnover rates, a checkstand design that provides better working conditions for employees should leverage retention drivers. Also with the universal design approach in the form of an increased accessibility and reduced cognitive and physical demands in task design, the employee pool widens and thus people with functional limitations with reduce

employment possibilities might find an opportunity in this industry and consider the cashier job as a long term career to follow.

As a conclusion, this project shows that universal design philosophy not only serve as a guideline to more accessible workstations but as added value to the whole front end retail business with the premise *"happy employee equals happy customer"*. Also the use of end users feedback as a source of inspiration for innovation proved to be a practical and useful way to identify and understand specific needs which plays an important role in workspace design. Furthermore, the hybrid checkout concept is the result of the convergence of stakeholder's needs that not only represents a solution for functional needs but an opportunity to provide better experience for customers and employees thus improving the company bottom's line.

Future work for this project should include a deeper study of the hybrid checkout concept within a real context. Also a deeper look into the customer needs is also a priority. Collaboration with technology suppliers and retail stores is imperative to refine the design and explore the challenges of manufacture and implementation. Functional prototypes should be challenging but valuable goal to this project. While much of the data used to create the universal design guidelines of grocery retail checkouts comes from research studies of related fields, it is not fully validated until it is tested in a real intended environment. Achieving this goal is not easy, activities like recruitment for studies prove to be a time consuming and frustrating task. However the potential of impact of a more refined and integral study should be enough motivation for this project to go on.

APPENDIX A

PRELIMINARY CONCEPTS

Figure 21Preliminary Concept 1

Figure 22Preliminary concept 2

Figure 23Preliminary concept 3

Figure 24Preliminary concept 4

Figure 25 Preliminary concept 5

Figure 26 Preliminary concept 6

Figure 27 Preliminary concept 7

Figure 28 Preliminary concept 8

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